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Candidate Region Extraction in Retina images through Extended Median Filter and Gabor Filter

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Abstract—Early detection of Diabetic Retinopathy is important task for patient vision. This diseases is affected by several abnormality, one of the first sign of disease is Microanerysms. To detect this abnormality, we have to extract all candidate regions for Microanerysms in retina images. In this paper, proposed three stages for extraction of candidate region from retina images. In the first stage, the system removes the noise in the retina image and in second stage applied contrast enhancement to retina image for improvement of candidate of lesions. In third stage, all possible candidates are extracted from retina images through Gabor filter. In this paper, proposed Extended Median filter for the removal of noise and with the combination of Gabor filter, matching filter and local entropy thresholding technique, this system ensemble to improve the candidate lesions extraction. The proposed system is evaluated using Driven database.

Keywords: Medical Image Processing, Diabetic Retinopathy, Microanerysms, Extended Median Filter, Gabor Filter.

I INTRODUCTION

Diabetic retinopathy is one of the major causes of blindness and it happen due to the variation in the blood vessels structure. Retinal vessels are part of circulation system, it is only part can be directly visualized and analyzed. Vascular network in retina is affected by diseases like diabetes and hypertension [1]. Changes in the blood vessels can be detected by the retinal vessel segmentation and this process gives the details about the vessel location. Through this detection of abnormality such as Microanerysms (MAs), exudates are easy [2, 3]. According to recent research outcomes that 285 million people are in the age group of 20-79 are affected by diabetes in the year 2010 worldwide [4]. 50.8 million People affected by diabetes in India in the year of 2010 [5].

Detection of abnormality is important task for detection of diabetic retinopathy. For this detection, extract the candidate region it gives all possible objects in MAs. These regions are given to feature extraction, based on the feature vector diagnose the disease of diabetic retinopathy. Due to the presence of noise in the retina images, it is difficult to identify the blood vessels. So need to remove the noise through preprocessing.

During image acquisition, image and video signals can be corrupted by salt and pepper noise. Image corrupted by the salt and pepper noise, the noisy pixel is denoted by maximum and minimum grey value. Maximum value is 255 and minimum value is 0. Many nonlinear filters have been proposed for removal of salt and pepper noise from the image. Among the most popular nonlinear filter is standard median filter, this filter replace the center pixel by the median value without considering whether it is uncorrupted or corrupted. So it remove some of the edges and it also applicable and effective one for low level noise density [6].

In [13, 14, 15 and 16], authors used median filter for the removal of noise in the retina image. Gaussian low pass filter is used to reduce the influence of noise through this accurately detect the Microanerysms in the classification stage is described in [17]. Mean

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filter and Gaussian filter in preprocessing step is described in [18] for removal of noise in retina image.

Basically segmentation of blood vessels is classified into two types that are pixel processing-based methods and vessel tracking methods [1]. In [19], author proposed the edge detection, matched filtering and region growing methods all combined and used for the detection of retinal blood vessels in retinal images. Combination of morphological filters and cross-curvature are used for the segmentation of blood vessels in the retina images are described in [20]. In [21] different image segmentation techniques are used for the segmentation of blood vessel in the retina images, survey of various segmentation of blood vessel techniques are described in [22].

This paper presents a candidate lesions segmentation through Gabor filter, matched filtering, entropy based thresholding. The main components of the fundus retina images are blood vessels; it is used to analyze the disease in the retina image. Noise removal is more important one, because due to noise the detection of blood vessel is difficult. So in this paper removal of noise is carried over through proposed extended median filter algorithm. Gabor filter is implemented for frequency selection.

The organization of the rest of this paper is as follows. Section 2, gives the related work, Section 3, describes about the new noise detection and filtering algorithm for retina image and the removal of blood vessel and extraction of candidate lesions. In section 4, experimental results are presented and it is compared with existing median filter with discussion. The conclusion of this paper is given in section 5

II METHODOLOGY

The system extracts the candidate region for increase the accuracy of classifier. In this paper candidate region extraction in three phase. In phase 1, it improves the noiseless retina image through proposed Extended Median filter. Phase 2, it improves the contrast of dark regions through smoothing and contrast enhancement. In the final phase, remove all blood vessels from the candidate pixel to improve the classifier accuracy.

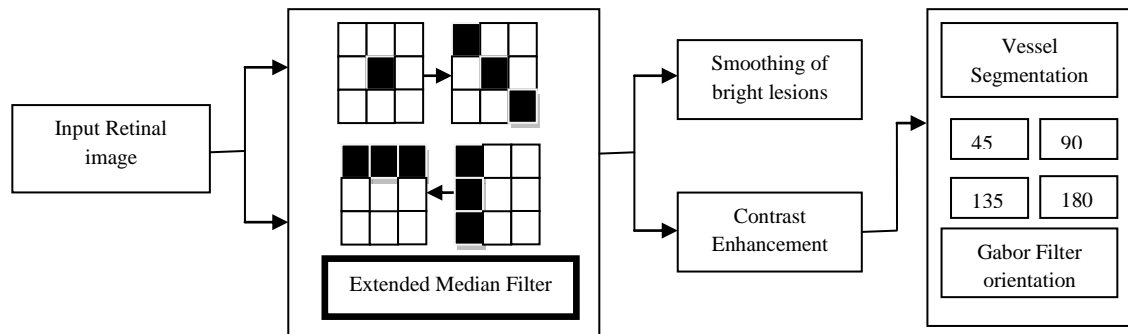


Figure 1. Block Diagram for the proposed system

A. Extended Median Filter:

Preprocessing is a vital process in an image processing. It is initial process and it is useful for extracting the features accurately and it would be helpful in classification stage. The captured fundus images are affected by noise due to movement of camera or respective patient in the time of image acquisition or unfavorable lighting condition. So in this process the images are denoised and enhanced. In medical field noise removal is difficult one because this may affect the whole image and their results. Many types of filter are available in medical images. Median filter is efficient in removal of noise and for smoothing the image. In this, proposed Extended Median Filter for removal of noise in the retina image. The input fundus image contains red, blue and green channel. In this paper green channel have to be taken for processing, because it is absorbed by blood vessels and reflected by retina pigment. It also has higher contrast between the blood vessels and retina background while red channel is rather saturated and the blue channel is dark. Noise is corrupted by salt and pepper noise, the noisy pixels are randomly are corrupted by two values are 0 and 255 [12]. There are four cases in our proposed algorithm for removal of noise in the retina image.

p_{11}	p_{12}	p_{13}
p_{21}	p_{22}	p_{23}
p_{31}	p_{32}	p_{33}

Figure 2. Sample 3×3 sliding window

Here $p_{11}, p_{12}, p_{13}, p_{21}, p_{22}, p_{23}, p_{31}, p_{32}$ and p_{33} are the pixels in the given 3×3 sliding window. First extract the green channel from the fundus image for further processing.

Case 1: Select 3×3 sliding window, in this case p_{22} is a processing pixel. Check whether the processing pixel contains noise (0/255 pixel value) or not. Following condition is satisfied

$$\left. \begin{array}{l} 0 < p_{22} < 255 \text{ uncorrupted pixel} \\ p_{22} = 0 \text{ or } 255 \text{ corrupted pixel} \end{array} \right\} \text{condition} \quad (1)$$

In this case, second condition is happened then sorted the nine pixels in the ascending order. We get a sorted sequence: $\overline{P_{11}}, \overline{P_{12}}, \overline{P_{13}}, \overline{P_{21}}, \overline{P_{22}}, \overline{P_{23}}, \overline{P_{31}}, \overline{P_{32}}, \overline{P_{33}}$. Through this sequence extracting the median value P_M . Then the corrupted pixel is replaced by the extracting median value P_M .

$$P_{22} = P_M \text{ for condition 2 (2)}$$

Case 2: After the P_{22} processing pixel, have to check diagonal pixel P_{11}, P_{22}, P_{33} in the same 3×3 sliding window. Check whether the diagonal pixel contains noise (0/255 pixel value) or not. Following condition is satisfied

$$\left. \begin{array}{l} 0 < P_{11}, P_{22}, P_{33} < 255 \text{ uncorrupted pixel} \\ P_{11}, P_{22}, P_{33} = 0 \text{ or } 255 \text{ corrupted pixel} \end{array} \right\} \text{condition (3)}$$

If the pixel is corrupted as noise then sorted the diagonal pixel P_{11}, P_{22}, P_{33} in an ascending order. We get a sorted sequence: $\overline{P_{11}}, \overline{P_{22}}$ and $\overline{P_{33}}$. Then extracting the median value for this sequence P_{DM} . Then the noisy pixel in the diagonal values are replaced by this median value P_{DM} .

$$\text{Already we know that } P_{22} = P_M.$$

$$P_{11}, P_M, P_{33} = P_{DM} \text{ for condition 2 (4)}$$

Case 3: After the diagonal pixels processing, check the vertical pixel in the same sliding window. Check whether the vertical pixel contains noise (0/255 pixel value) or not. Following condition is satisfied.

$$\left. \begin{array}{l} 0 < P_{11}, P_{21}, P_{31} < 255 \text{ uncorrupted pixel} \\ P_{11}, P_{21}, P_{31} = 0 \text{ or } 255 \text{ corrupted pixel} \end{array} \right\} \text{condition (5)}$$

If the three pixels are corrupted by noise, then we have to sort these pixels in ascending order. Ascending sorted sequence are $\overline{P_{11}}, \overline{P_{21}}$ and $\overline{P_{31}}$. Extracting median value for these sorted sequence is P_{VM} . Corrupted pixel in the vertical values are replaced by this median value P_{VM} . We know that $P_{11} = P_{DM}$ from case 2.

$$P_{DM}, P_{21}, P_{31} = P_{VM} \text{ for condition 2 (6)}$$

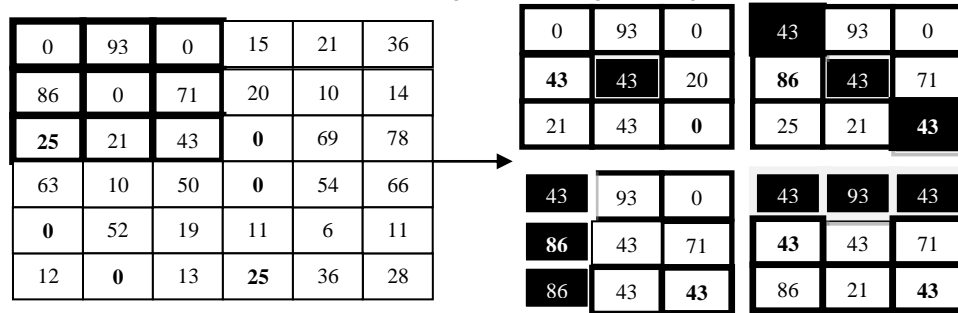
Case 4: After the vertical pixel processing, check the horizontal pixel in the same sliding window. Check whether the horizontal pixel contains noise (0/255 pixel value) or not. Following condition is satisfied.

$$\left. \begin{array}{l} 0 < P_{11}, P_{12}, P_{13} < 255 \text{ uncorrupted pixel} \\ P_{11}, P_{12}, P_{13} = 0 \text{ or } 255 \text{ corrupted pixel} \end{array} \right\} \text{condition (7)}$$

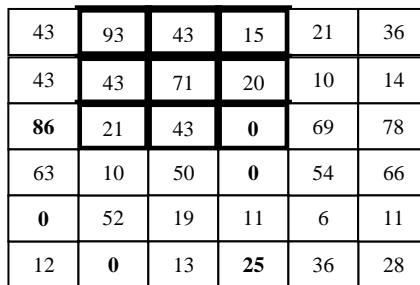
If the horizontal pixels are corrupted by noise, then replace this noisy pixel by median value P_{HM} of these three horizontal pixels, that are extracted from the sorted ascending sequence of these three values $\overline{P_{11}}, \overline{P_{12}}$ and $\overline{P_{13}}$. We know that $P_{11} = P_{DM}$ from case 2

$$P_{DM}, P_{12}, P_{13} = P_{HM} \text{ for condition 2 (8)}$$

Figure 3 gives the example for proposed extended median filter algorithm. Fig 3.a is the first 3×3 sliding window. After the fifth, diagonal, vertical and horizontal pixels, it switch over to second sliding window it is given in fig. 3.b



(a)



(b)

Figure 3. Example for proposed Extended Median Filter algorithm (a) First sliding window and their function of fifth, diagonal, vertical and horizontal pixel (b) Second sliding window

B. Smoothing and Contrast Enhancement:

After the efficient noise removal technique, smoothing the image is needed. Morphological operation of opening and closing is done with structural element and it is described as:

$$\text{image opening: } X^{(sB)}(f) = X^{(sB)}[\alpha^{(sB)}(f)] \quad (9)$$

$$\text{image closing: } Y^{(sB)}(f) = Y^{(sB)}[\beta^{(sB)}(f)] \quad (10)$$

In the above two equation sB is taken as structuring element B of size s and f is the filtered image. The output of smoothing image contains the dark lesions. For easy detection in the classification stage, to improve the lesions using adaptive contrast enhancement technique.

C. Gabor Filter:

Candidate region is a small circular object, it is shown as dark red dot and patches in the retina images. This region can be identified by our eye but sometime it can be varied through their texture, contrast and blood vessels. Through this variation in the images it can be difficult to identified, so they are extracted through Gabor filter and blood vessels are segmented.

Gabor filter have been used in texture analysis, image processing for their excellent properties of spatial frequency localization and to compute the simple cells in the visual cortex [7-9]. Gabor filter is important for frequency tuning and orientation selection. Due to this property, rotate the retina image and detect the blood vessels through this orientation. Basically Gabor filter centered at (0,0) in the spatial domain is described as

$$G(a, b, v_a, v_b, \sigma_a, \sigma_b, \theta) = \frac{1}{\sqrt{\pi\sigma_a\sigma_b}} e^{-\frac{1}{2} \left[\left(\frac{m_1}{\sigma_a} \right)^2 + \left(\frac{m_2}{\sigma_b} \right)^2 \right]} e^{i(v_a a + v_b b)} \quad (11)$$

In the above equation $m_1 = a \cos \theta + b \sin \theta$ and $m_2 = -a \sin \theta + b \cos \theta$, spatial frequency is indicated by v_a and v_b , standard deviation is represented by σ_a and σ_b and finally θ denotes the orientation.

Spatial frequency gives the relation that is

$$v_a = \omega \cos \theta \text{ and } v_b = \omega \sin \theta \quad (12)$$

In the above relation ω gives the relation that is

$$\omega = \sqrt{v_a^2 + v_b^2} \quad (13)$$

Based on equation (2 & 3), equation 1 changes into

$$G(a, b, \omega, \sigma, r, \theta) = \frac{1}{\sqrt{\pi r \sigma_a}} e^{-\frac{1}{2} \left[\left(\frac{m_1}{\sigma_a} \right)^2 + \left(\frac{m_2}{r \sigma_a} \right)^2 \right]} e^{i \omega m_1} \quad (14)$$

In the above equation $r = \frac{\sigma_b}{\sigma_a}$, it is an elliptical Gaussian envelope aspect ratio. The Gabor filter is centered at $C(a', b')$ is simply described as $(a' - a, b' - b, \omega, \sigma, r, \theta)$. Given input image I is centered at (a', b') is computed as the convolution as

$$Z = \sum_a \sum_b I(a, b) G(a' - a, b' - b, \omega, \sigma, r, \theta) \quad (15)$$

The maximum Gabor filter using frequency and scale values is evaluated using below equation for θ spanning from 45° upto 180° at steps of 45° .

$$M_f(\sigma, v) = \max |v(\sigma, v, \theta)| \quad (16)$$

After the extraction of candidate regions through Gabor filter. This region contains false lesion regions in their blood vessels pixels. So we have to remove that false lesion region for further processing. The accurate segmentation of blood vessel is carried out through matched filtering, entropy based thresholding, length filtering, and vascular intersection detection is described detailed in [10, 11].

D. Blood vessel segmentation:

Matching filter is used for the segment of blood vessels in the retina image. Equation for the matching filter is described as:

$$f(a, b) = -\exp\left(\frac{-a^2}{2\sigma^2}\right), \text{ for } |b| \leq \frac{L}{2} \quad (17)$$

In the above equation length of the segmentation is denoted by L, in which the vessel has fixed orientation. Blood vessel is oriented in different angles; kernel is needed to rotate to all possible angles. Blood vessel segments are extracted from the retinal images. Local entropy based threshold technique is implemented in this paper for extraction of vessels

I. EXPERIMENTAL RESULT

The proposed technique is tested for fundus retina image. Performance of proposed noise technique is computed using performance metrics such as PSNR, MSE. The images are collected from the driven database.

$$MSE = \frac{1}{ab} \sum_{i=0}^{a-1} \sum_{j=0}^{b-1} (I_{ij} - F_{ij})^2 \quad (18)$$

$$PSNR = 10 \times \log_{10} \frac{255^2}{MSE} \quad (19)$$

MSE denotes the Mean Square Error, PSNR indicate peak signal-to-noise ratio. I define the input image and F indicate filtered image. The proposed technique is compared with existing median filter through performance metrics.

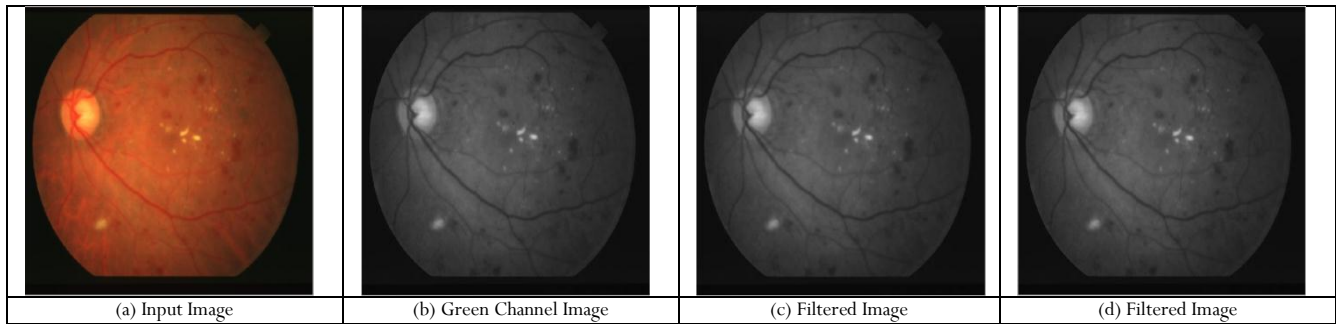


Figure 4. Noise Removal: (a) Original retina image; (b) green channel obtained from (a); (c) filtered output from existing median filter; (d) filtered output from proposed extended median filter

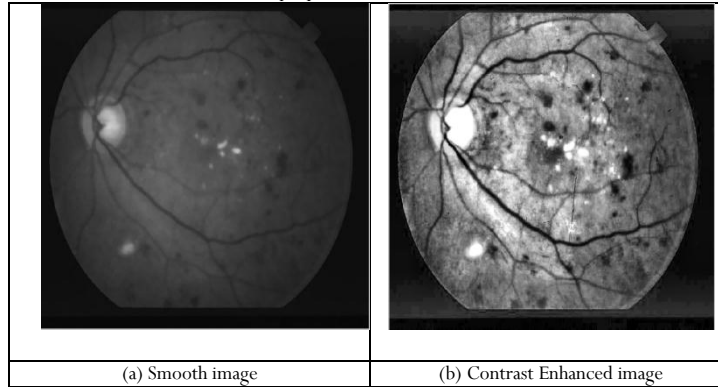


Figure 5. Red lesions Enhancement (a) Smooth image obtained from fig. 4(d); (b) contrast enhanced image obtained from (a)

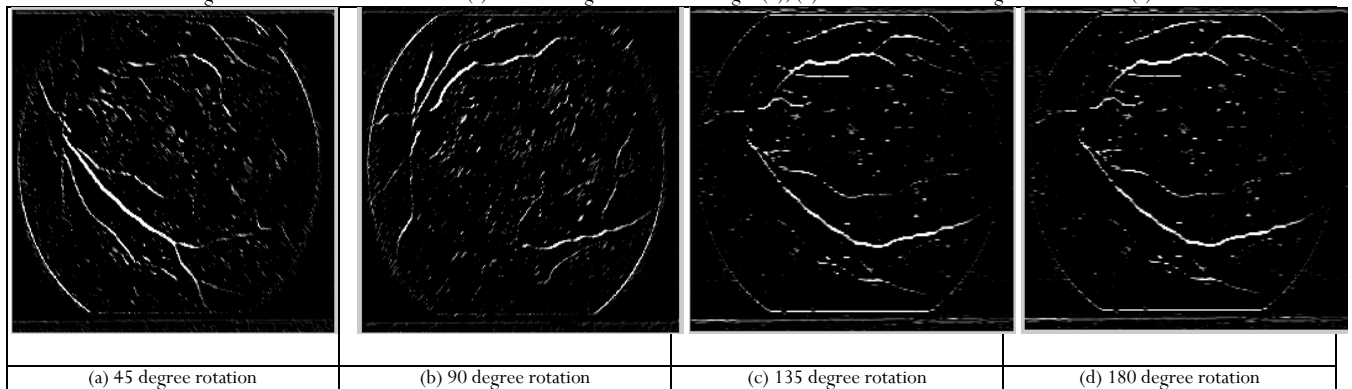
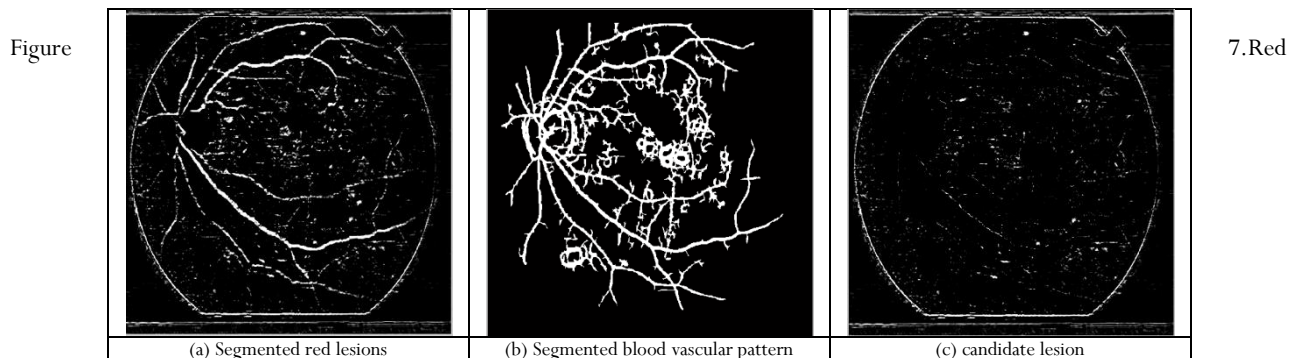


Figure 6. Gabor Filter banks and their orientation



candidate lesions extraction. (a) Segmented red lesions containing spurious region; (b) segmented blood vascular pattern using [10, 11]; (c) candidate lesions after vessel subtraction

TABLE 1.

PSNR, MSE FOR TWO ALGORITHMS FOR RETINA IMAGE

Image	Existing Median Filter		Proposed Extended Median filter	
	PSNR	MSE	PSNR	MSE

Image 1	48.7633	0.8713	64.9034	0.0213
Image 2	48.7344	0.8771	65.7270	0.0175
Image 3	48.0464	1.0276	63.3963	0.0300
Image 4	48.3754	0.9527	65/3643	0.0191
Image 5	49.7443	0.6951	64.9034	0.0212

The PSNR, MSE and RMSE are evaluated for simulation results and comparison of performance between proposed extended median filter and standard median filter is given in Table 1. Figure 4 illustrates the output of noise removal technique. Fig. 4 (a) illustrates the original retina image obtained from driven database. The input image contains red, blue and green channel, in the three channels green channel is more contrast. So extraction of Green channel of the retina image is illustrated in Fig. 4 (b). This green channel is used for further processing. Fig. 4 (c & d) provides the output of the standard median filter and proposed extended median filter. From the table clearly observed that the proposed extended median filter algorithm provides better result than existing median filter based on higher PSNR and lower MSE.

Enhancement of regions are illustrates in fig. 5; fig.5. (a) Shows the opening and closing of retina image it contains dark lesions but need enhancement and it is shown in fig.5. (b). Gabor filter orientation with 45^0 , 90^0 , 135^0 and 180^0 is shown in fig. 6. Through this orientation easily observe the visualization of blood vessels in all direction. Fig. 7 shows the segmentation results before and after the removal of blood vessels. This removal is helpful for removing the false candidate present in the retina image.

III CONCLUSION

Automatic detection of diabetic retinopathy is one of the recent researches. The first manifestation of diabetic retinopathy is Microanerysms in retina image. This work is proposed to segment the candidate lesions from the blood vessels. The detection of blood vessel is crucial work, because it can be affected by some noise. So first noise removal is needed, in this paper noise removal is obtained by proposed algorithm of extended median filter. This algorithm is compared with existing median filter with performance metrics such as PSNR and MSE. The existing median filter only checks the fifth pixel in the given sliding window and it is switch over next sliding window. But proposed extended median filter not only fifth pixel, also checks the diagonal, vertical and horizontal pixels of the same sliding window. After this processing, it switches over to second sliding window. Experimental result proves that the proposed extended median filter algorithm gives better result than the existing median filter in terms of PSNR and MSE. After the noise removal technique, morphological operation of smoothing and contrast enhancement is carried for easily detection of blood vessel needed for accurately classified the diseases. Gabor filter is used in this paper for the extraction of different level or orientation of blood vessels. Gabor filters are applied to extract the blood vessels. Then finally segment the candidate lesions after the removal of blood vessels through matching filter and local entropy thresholding. This candidate lesions regions further given for feature vector, through this classification is carried and detect the abnormality in the diabetic retinopathy.

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